EFFECT OF YOGA INTERVENTION ON MUSCLE ACTIVITY, PLANTAR PRESSURE DISTRIBUTION AND STATIC STABILITY IN NON-YOGIC PRACTITIONERS

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A

Synopsis

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TABLE OF CONTENTS

CHAPTER		PAGE NO.
I	**INTRODUCTION**	**1-6**
	Statement of the problem	
	Objectives of the study	
	Delimitations	
	Limitations	
	Hypothesis	
	Definition and explanation of the term	
	Significance of the study	
II	**REVIEW OF RELATED LITERATURE**	**7-8**
III	**METHODOLOGY**	**9-11**
	Selection of subjects	
	Selection of variables	
	Administration of test	
	Methods of data collection	
	Statistical technique	
IV	**BIBLIOGRAPHY**	**12-16**

DEPARTMENT OF SPORTS BIOMECHANICS

Certificate

I hereby declare that the short synopsis "**Effect of yoga intervention on muscle activity, plantar pressure distribution and static stability in non-yogic practitioners**" being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Physical education under the department of Sports Biomechanics of Lakshmibai National Institute of Physical Education, Gwalior during the academic year 2022-23.

It is a bonafide record of original work carried out under the supervision Dr. Padmakar and has not been submitted in full or part to any other university or institute for a degree.

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ABSTRACT

Yoga, an ancient mind-body practice, is increasingly recognized as a modern therapeutic tool to improve musculoskeletal function, postural control, and neuromuscular efficiency. Its integration into physiotherapy and rehabilitation has shown potential benefits for flexibility, strength, and balance. However, limited scientific evidence exists on its direct impact on muscle activity, plantar pressure distribution, and static stability, particularly in individuals without prior yoga experience. This study aims to evaluate the effects of a structured yoga intervention on these parameters in non-yogic practitioners. An experimental pre-post design will be used involving healthy adults with no history of yoga practice. Baseline assessments will include surface electromyography (sEMG) of lower limb muscles (gastrocnemius, soleus, vastus medialis, and vastus lateralis), baropodometric analysis of plantar pressure (peak pressure of foot region), and stabilometric analysis of static stability (center of pressure displacement, sway area, sway velocity). Participants will then undergo an 8-12-week supervised yoga program focused on postures that enhance balance, coordination, and muscle activation. Post-intervention, all assessments will be repeated. The intervention is expected to result in improved muscle recruitment and coordination, more balanced plantar pressure distribution, and enhanced postural steadiness. Reduced postural sway and improved control of center of pressure are anticipated, indicating better static stability. These outcomes would support yoga as an effective approach for enhancing neuromuscular function and postural control, even among those new to the practice. This study aims to provide empirical evidence on the biomechanical and physiological benefits of yoga in non-yogic individuals, contributing to its validation as a preventive and rehabilitative intervention for postural and neuromuscular health.

Keywords: Yoga Intervention, Muscle Activity, Plantar Pressure Distribution, Static Stability, Electromyography (EMG), Postural Control

INTRODUCTION

In recent decades, yoga has transitioned from being primarily an Eastern philosophical practice to gaining widespread recognition as a therapeutic intervention across the globe (Field, 2016). This ancient practice, originating in India over 5,000 years ago, has been increasingly adopted in Western healthcare systems due to its potential benefits for physical fitness, mental well-being, and overall health (Cramer et al., 2016). Yoga combines physical postures (asanas), breathing techniques (pranayama), and meditation, offering a holistic approach to health enhancement (Büssing et al., 2012). The growing scientific interest in yoga has led to numerous studies investigating its effects on various physiological and psychological parameters, yet specific aspects such as muscle activation patterns, plantar pressure distribution, and postural stability remain relatively unexplored, particularly in relation to balance-oriented yoga poses (Gothe & McAuley, 2016). Balance and postural control represent fundamental components of human movement and physical function, involving the integration of sensory information from visual, vestibular, and somatosensory systems (Horak, 2006). These complex mechanisms are essential for daily activities and are particularly crucial for athletic performance and injury prevention (D. Winter, 1995). Impaired balance can significantly affect quality of life and increase the risk of falls across different age groups (Rubenstein, 2006). Therefore, interventions that enhance balance and postural stability have important implications for both general health promotion and rehabilitation settings. Yoga poses, particularly standing asanas such as Vrikshasana (Tree Pose), Garudasana (Eagle Pose), Natrajasana (Dancer's Pose), and Virabhadrasana III (Warrior III Pose), have been traditionally believed to improve balance, strength, and mind-body awareness (Iyengar, 1995a). These poses challenge the practitioner's ability to maintain equilibrium through various body positions that alter the base of support and center of gravity, potentially stimulating adaptive responses in the neuromuscular system (Tiedemann et al., 2013). However, the specific biomechanical and neurophysiological mechanisms underlying these adaptations warrant further scientific investigation. The human foot, serving as the primary interface between the body and the ground, plays a critical role in maintaining postural stability (Kavounoudias et al., 1998). Plantar pressure distribution analysis provides valuable insights into how forces are transmitted through the foot during static and dynamic activities (Orlin & McPoil, 2000). Changes in plantar pressure patterns following specific interventions can reflect adaptations in postural control strategies and weight-bearing distributions (Deepashini et al., 2014). The baropodometric platform represents a sophisticated tool for quantifying these pressure distributions across various foot regions,

including the toes (T1-T5), metatarsals (M1-M5), midfoot (MF), and heel regions (MH, LH), offering objective measurements of potential intervention effects (Cuccia, 2011). Concurrently, electromyography (EMG) enables the assessment of muscle activation patterns and timing, providing crucial information about neuromuscular control during balance tasks (Luca, 1997). Lower limb muscles, including the gastrocnemius, soleus, vastus medialis, and vastus lateralis, contribute significantly to postural stability through their roles in ankle and knee joint control (Horak et al., 1989). Analyzing the activity of these muscles during and after yoga interventions can reveal adaptations in motor control strategies that may underlie improvements in balance performance (Ni et al., 2014).

Several studies have demonstrated the positive effects of yoga on balance parameters. For instance, Jeter et al., (2014) conducted a systematic review highlighting significant improvements in balance outcomes following yoga interventions across various populations. Similarly, Youkhana et al., (2016) reported enhanced static and dynamic balance among older adults after regular yoga practice. However, these studies primarily utilized clinical balance assessment tools rather than sophisticated biomechanical analyses, limiting our understanding of the underlying mechanisms. Research specifically examining the effects of yoga on muscle activity has shown promising results. Okubo et al., (2010) found altered muscle activation patterns following a yoga intervention, suggesting enhanced neuromuscular efficiency during balance tasks. Additionally, Salem et al., (2013) observed improved lower extremity muscle activation timing and coordination after a yoga-based exercise program. These findings suggest that yoga may optimize muscle recruitment strategies, potentially contributing to enhanced postural control. Regarding plantar pressure distribution, research is more limited. Polsgrove et al., (2016) reported altered foot pressure patterns following a yoga intervention, indicating potential changes in weight-bearing strategies. However, comprehensive analyses of pressure changes across specific foot regions after yoga practice remain scarce. Understanding these changes could provide valuable insights into how yoga modifies the foot-ground interaction, potentially explaining improvements in balance performance. The center of pressure (COP) displacement serves as a key parameter for quantifying postural sway and stability (Prieto et al., 1996). Reduced COP excursions typically indicate improved postural control, while increased mediolateral and anteroposterior oscillations generally suggest diminished stability (Duarte & Freitas, 2010). Previous research has shown that yoga practice can reduce COP displacement parameters, indicating enhanced static stability (Donath et al., 2016). However,

the relationship between these improvements and changes in muscle activation patterns or plantar pressure distribution remains unclear.

The novelty of this study lies in its comprehensive approach to examining the effects of specific yoga poses on multiple parameters related to postural control simultaneously. By integrating EMG and baropodometric assessments, this research aims to provide a more complete understanding of the neuromuscular and biomechanical adaptations following yoga practice. This integrated analysis may reveal relationships between changes in muscle activation, plantar pressure distribution, and overall stability that have not been previously identified. Given the increasing healthcare costs associated with balance-related injuries and the growing interest in yoga as a therapeutic intervention, understanding the specific effects of yoga on postural control mechanisms has significant implications. This knowledge could inform more targeted yoga interventions for various populations, including athletes seeking performance enhancement, older adults aiming to reduce fall risk, or individuals undergoing rehabilitation (Schmid et al., 2010). This study aims to investigate the effects of a structured yoga intervention, focusing on balance-oriented poses, on muscle activity patterns, plantar pressure distribution, and static stability parameters in non-yogic practitioners. By analyzing these variables using sophisticated biomechanical assessment tools, this research seeks to elucidate the mechanisms underlying yoga-induced improvements in postural control. The findings could contribute to the development of evidence-based yoga protocols for balance enhancement and inform future research directions in this rapidly evolving field

STATEMENT OF THE PROBLEM

The problem of the study stated as **"Effect of yoga intervention on muscle activity, plantar pressure distribution and static stability in non-yogic practitioners"**

OBJECTIVES OF THE STUDY

The research work will be carried out with the following objectives in perspective:

- The prime objective of the present study is to know the effect of yoga intervention on muscle activity, plantar pressure distribution and static stability in non-yogic practitioners.
- The objective of the present study is to know the effect of yoga intervention on muscle activity in non-yogic practitioners.

- The objective of the present study is to know the effect of yoga intervention on plantar pressure distribution in non-yogic practitioners.
- The objective of the present study is to know the effect of yoga intervention on static stability in non-yogic practitioners.

DELIMITATIONS

- This study will be delimited to the subject's age belonging to 18-25.
- This study will be confined to 30 male non yogic practitioners only. •

The study will be delimited to single-leg(right) standing Asanas only.

- This study will be confined to male non yogic practitioners of the LNIPE Gwalior campus.
- The study will be delimited to the selected lower muscles which are as follows:

1. Gastrocnemius
2. soleus
3. vastus medialis
4. vastus lateralis.

- The study will be delimited to the selected standing Asanas which are as follows:

1. vrikshasana
2. Garudasana
3. Natrajasana
4. Virabhadrasana III

- The study will be delimited to the selected foot varibles are T1, T2, T3, T4, T5, M1, M2, M3, M4, M5, MF, MH, and LH (maximum pressure)
- The study will be delimited to the selected stabilometric variable which are as follows:
    - Mediolateral oscillation.
    - Anterior-posterior oscillation.
    - center of pressure distance.

LIMITATIONS

- Certain factors like lifestyle, body structure, personal habits, and family heredity will not be taken into consideration in this study.
- Certain factors like diet, environmental and climatic conditions, and economic background were not taken into consideration. The day-to-day routine work will not be controlled.
- The attitude of the subjects and the effort put in by them in performing the test will not be controlled.

HYPOTHESIS

- There would be a significant effect of yoga intervention on muscle activity.
- There would be a significant effect of yoga intervention on T1, T2, T3, T4, T5, M1, M2, M3, M4, M5, MF, MH, LH (maximum pressure).
- There would be a significant effect of yoga intervention on mediolateral oscillation.
- There would be a significant effect of yoga intervention on anteroposterior oscillation.
- There would be a significant effect of yoga intervention on the center of pressure distance.

DEFINITION AND EXPLANATION OF THE TERM

1. **YOGA:** The word yoga is derived from the Sanskrit root yuj meaning to bind, join, attach, and yoke, to direct and concentrate one's attention on, to use, and apply (Iyengar, 1995b).
2. **Centre of Pressure:** The center of pressure is the projection on the ground plane of the centroid of the vertical force distribution. In effect, the CP is the location where the resultant force vector would act if it could be considered to have a single point of application (Benda et al., 1994).
3. **Mediolateral Oscillation:** Mediolateral oscillation refers to the side-to-side (left-to-right) movement of the body's center of pressure (COP) or center of mass (COM) during standing or locomotion, and is a key indicator of postural stability and balance control. Excessive mediolateral sway is often associated with increased fall risk, particularly in older adults and individuals with balance impairments (D. A. Winter et al., 1998).
4. **Anteroposterior Oscillation:** Anteroposterior oscillation refers to the sway or displacement of the body in the front-to-back (anterior-posterior) direction during standing or movement, often used as a measure of postural stability and balance control. This parameter is commonly

assessed through stabilometric analysis, where increased anteroposterior sway may indicate impaired balance or neuromuscular control (D. A. Winter et al., 1998).

5. **Maximum pressure:** Maximum pressure refers to the highest force per unit area exerted on a specific region of the plantar surface of the foot during static or dynamic activities. It is a critical parameter in baropodometric analysis, used to evaluate foot biomechanics and load distribution. High localized maximum pressure is often associated with biomechanical imbalances and may contribute to foot pathologies or increased risk of injury (Menz et al., 2005).
6. **EMG:** The electrical potential of muscles is graphically recorded in electromyography (EMG). In order to detect and amplify the motor unit action potentials of the muscles under study, the basic EMG technique entails inserting either surface or intramuscular electrodes into the muscles. After that, these can be examined manually or with the aid of a computer-based analysis tool (Suvinen & Kemppainen, 2007).

SIGNIFICANCE OF THE STUDY

- Result of the study highlighted the effect of standing asanas on muscle activity, selected foot area variables with maximum pressure and static stability.
- The findings of the study will be added to the existing knowledge in the area and will be beneficial for the players, coaches, and researchers for getting feedback.
- The study will throw new light on the field of sports biomechanics for further research.

Chapter II

REVIEW OF RELATED LITERATURE

Kumar & Rathore (2018) Analyzing foot pressure is helpful in clinical diagnosis. Possible applications include the diagnosis of back injuries, prevention of diabetic foot ulceration, and adaptation of insoles for orthopedic applications. Consequently, several approaches to measure foot pressure distributions exist. Most people pay little attention to their feet, feet have to withstand physical strain occurring when standing for hours, carrying heavy objects, or moving rapidly during sports. In volleyball player's take-off and landing plays a great role during spiking and blocking, so by knowing the bilateral difference in application of pressure and oscillation we may know about their status of joints and also prevent it from injury. Ten males Inter University right-handed volleyball players of LNIPE, Gwalior were selected as subjects for the study by employing purposive sampling. Players were asked to stand on Baropodometric Platform BTS with dominant foot and non-dominant foot with a gap of 3 minutes in between so that fatigue will not affect the oscillation. Initially tested lower limb was alternated between right and left in a consecutive fashion. Data obtained from the Baropodometric Platform BTS were converted to Microsoft Excel, where the following parameters were analyzed i.e. anteroposterior oscillation (APO) and mediolateral oscillation (LO) directions, the Average speed of oscillation and displacement of Center of Pressure (COP) Descriptive statistics and T-test were used for the comparison in dominant foot and non-dominant foot of volleyball players at 0.05 level of significance. The dominant foot also showed less oscillation in both aspect anterior posterior oscillation and lateral oscillation which shows more joint stability and also tells about the better functioning of propiroceptors ability. May be due to more laxity in joints of non-dominant foot the speed of oscillation also showed significantly higher than dominant foot causes greater displacement in center of pressure.

(Kumari et al., 2018) The present study was aimed at comparative analysis of Foot Pressure Distribution on single leg balancing asana in eyes open and eyes closed. The study was conducted on 15 male students from LNIPE Gwalior, age ranging from 18–25. Data were collected on BTS P-Walk (Baropodometric Pressure Platform) on Vrikshasana in eyes open and eyes closed. All subjects were asked to performed single-leg balancing asana in eyes open and eyes closed to measure the C.O.P Distance and Average speed on pressure platform. Data was recorded for 10 seconds, when subjects were on the pressure platform in both conditions i.e. eyes open and eyes closed. It was hypothesized that there would be significant difference in

eyes open and eyes closed. Paired T-test was employed for the analysis of result at 5% level of significance. Finally, significant differences were found in eyes open and eyes closed. In eyes closed selected variables were found significantly higher than eyes open with mean and SD of visual (183.89±37.36) and non-visual (567.03±263.78) of COP distance and average speed of visual (18.24±3.63) and non-visual (64.52±29.69) on the vrikshasana with the static foot planter pressure distribution of the subjects on the pressure platform. Thus, it can be concluded that centre of pressure distance and average speed were changed in eyes open and eyes closed.

Lobo Da Costa et al.,(2013) The purpose of this study was to describe the effects of lower limb positioning and shoe conditions on stability levels of selected single leg ballet poses performed in demi-pointe position. Fourteen female non-professional ballet dancers (mean age of 18.4 2.8 years and mean body mass index of 21.5 2.8 kg/ m2) who had practiced ballet for at least seven years, without any musculoskeletal impairment volunteered to participate in this study. A capacitive pressure platform allowed for the assessment of center of pressure variables related to the execution of three single leg ballet poses in demi pointe´ position: attitude devant, attitude derrie´re, and attitude a la second. Peak pressures, contact areas, COP oscillation areas, anterior– posterior and medio-lateral COP oscillations and velocities were compared between two shoe conditions (barefoot versus slippers) and among the different poses. Barefoot performances produced more stable poses with significantly higher plantar contact areas, smaller COP oscillation areas and smaller anterior–posterior COP oscillations. COP oscillation areas, anterior–posterior COP oscillations and medio-lateral COP velocities indicated that attitude a la second is the least challenging and attitude derrie´re the most challenging pose.

Chapter III

METHODOLOGY

In this chapter, the selection of subjects, selection of variables, criterion measures, administration of tests, collection of data, and statistical technique applied will be described.

SELECTION OF SUBJECTS

1. Male non yoga practitioner (N -30) will be selected for this study. 15 students for the experimental group and 15 for the control group.

2. Age ranges of subjects will be 18-25 years, respectively.

SELECTION OF VARIABLES

Dependent variables

- T1, T2, T3, T4, T5, M1, M2, M3, M4, M5, MF, MH, LH (maximum pressure).
- Mediolateral oscillation.
- Anterior-posterior oscillation.
- center of pressure distance.

Leg muscles

- Gastrocnemius
- soleus
- vastus medialis
- vastus lateralis.

Independent variables

- vrikshasana
- Garudasana
- Natrajasana
- Virabhadrasana III

ADMINISTRATIONS OF TEST

Experimental design

The study will be formulated as a truly random group design. Consisting of a pre-test and post-test the subjects (n =30) will be randomly assigned two equal groups of fifteen male students each from LNIPE, Gwalior. The groups shall be assigned as experimental groups and control groups respectively. Pretest will be conducted for all the subjects on a selected area of foot and Variables such as T1, T2, T3, T4, T5, M1, M2, M3, M4, M5, MF, MH, LH where these will measure maximum pressure and stabilometric variables such as lateral oscillation, anterior-posterior oscillation, the center of pressure. Experimental groups shall participate in their respective Yogic Practice group of LNIPE, Gwalior for a period of 9 weeks. The post-test will be conducted on the above-said dependent variables after a period of 9 weeks in the respective treatments. The training Program will be scheduled from 4 to 5 p.m. from Monday to Friday in progression.

METHODS OF DATA COLLECTION

According to the study of true random group design for the experimental group and control group, pre-data will be collected for both groups in BTS P-Walk and BTS EMG from the sports biomechanics lab of LNIPE Gwalior. After nine weeks of treatment, post-treatment data will be collected from the above-mentioned. Before the collection of data, the researcher will give a demonstration of the single leg (right) standing asana on a baropodometric pressure platform in the sports biomechanics lab of Lnipe Gwalior. After nine weeks of treatment, post-treatment data will be collected from the above-mentioned Before the collection of post data, the researcher will again give a demonstration of the single leg (right) standing asana on a baropodometric pressure platform, and after that, he will collect the data, which will be displayed on the screen and perform by the subjects.

For collecting pre and post data of muscle activity during standing asanas, BTS EMG will be used by the researcher.

STATISTICAL TECHNIQUE

Based on the objectives of the study, the following statistical techniques will be used:

- To know the effect of yoga intervention on the muscle activity of non-yogic practitioner one -Way ANOVA will be used.
- To know the effect of yoga intervention on the foot area with a maximum pressure of yoga practitioner one -Way ANOVA will be used.
- To know the effect of yoga intervention on mediolateral oscillation, anteroposterior oscillation and center of pressure distance of yoga practitioner paired t-test will be used.

The significance of the hypothesis will be tested at the.05 level. All the statistical procedures will be performed on computer software, the Statistical Package for Social Sciences (SPSS 22).

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